PRINCIPAL COMMERCIAL PLANT FIBERS.

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Introduction.

One of the most important manufacturing industries of this country is that which includes the various lines of textiles. Leaving out the silk and woolen mills, which use chiefly animal fibers, there are the cotton factories, the linen and jute mills, and the twine and cordage mills, which use plant fibers exclusively. These number about 1,200 distinct establishments, representing an invested capital of more than $500,000,000 and giving productive employment to more than 300,000 persons.

The source of the raw material required by this great industry is an item of no small interest. Most of the cotton is produced in our Southern States, but nearly all the other vegetable fibers are imported. The importations of raw fibers, including cotton, during the fiscal year ended June 30, 1903, amounted to $46,161,172. These figures cover only the raw fiber. The importations of all the different kinds of textile plant fibers in the various stages of manufacture, from yarn and coarse twine to fine woven goods, laces, and hosiery, amount annually to more than $80,000,000.

Classification of Fibers.

Vegetable fibers used in textile manufactures in this country may be readily divided into three rather distinct classes, either from the standpoint of the manufacturer, who regards the kind of machinery or process of treating the fiber and the character of the goods produced, or from the viewpoint of the botanist, who regards the character of the plant and the manner in which the fiber is borne. These three classes are:

(1) The cottons, with soft, lint-like fiber ½ inch to 2 inches long, composed of single cells, borne on the seeds of different species of cotton plants.

(2) The soft fibers, or bast fibers, including flax, hemp, and jute; flexible fibers of soft texture, 10 to 100 inches in length, composed of many overlapping cells, and borne in the inner bark of the plants. (Pl. XLV, fig. 1.)

(3) The hard, or leaf, fibers, including manila, sisal, mauritius, New Zealand fibers, and istle, all having rather stiff, woody fibers 1 to 10 feet long, composed of numerous cells in bundles, borne in the tissues of the leaf or leaf stem. (Pl. XLV, fig. 2.)

COTTONS.

Cotton easily outranks both of the other classes combined in the quantity used, the capital invested in its production and manufacture, and the diversity of its uses. It is produced at a comparatively small cost, is spun into yarn with greater ease and rapidity than any other vegetable fiber, and is readily adapted to nearly all forms of woven fabrics. These facts have led to its extensive use among all civilized nations.

AMERICAN UPLAND COTTON.

Among the half dozen rather distinct types of cottons recognized by producers and manufacturers the most extensively used is the American Upland (Pl. XLVI, fig. 1). This is cultivated in the Southern States from Virginia to Oklahoma and Texas. It has given such good results here that seed has been taken to all other cotton-growing regions, and now American Upland cotton is cultivated in Russian Turkestan, Persia, India, British and German West Africa, Brazil, and Porto Rico.

There are more than a hundred recognized horticultural varieties of Upland cotton in cultivation, all belonging to one botanical species, *Gossypium hirsutum*, native in the American tropics. The original wild plants in the tropical zone were perennials, but the plant is cultivated as an annual. The seed is sown in the spring, in drills, rarely in checks, and cultivated in the same manner as corn. The lint, or cotton of commerce, is borne on fuzzy seeds in seed pods ("bolls"—Pl. XLV, fig. 3) which burst open at maturity (September to November in the Southern States), exposing the fluffy wool-covered seed clusters ready for picking. The lint is separated from the seeds by ginning and packed in bales for shipment.

The average annual production of Upland cotton in the Southern States during the past five years has ranged between 9,500,000 and 11,000,000 bales of 500 pounds each. The prices during this period have varied from 6 to 16 cents per pound. The value of the crop, more than $500,000,000, exceeds that of any other crop, except corn, produced in this country.

The lint of Upland cotton consists of fibers one-half inch to 1½ inches in length, white, appearing when highly magnified like flattened tubes or collapsed fire hose, spirally twisted. This twist enables the fibers to cling together, making a strong thread when spun; furthermore, it permits them to bend without breaking, enabling them to be spun into a hard-twisted, yet flexible, yarn or thread.

Upland cotton is spun into yarn, and the yarn is twisted into sewing thread, wrapping twine, or small sizes of rope, is braided into cord, knit into hosiery, or woven into cloth, ranging from the standard unbleached factory goods to fancy velveteens and novelties in colors. Raw cotton is also mixed with wool, and cotton yarn often appears as a mixture in woolen, silk, and linen goods.

SEA ISLAND COTTON.

Sea Island cotton is obtained from a plant known technically as *Gossypium barbadense* (Pl. XLVI, fig. 2). This species was found in the West Indies when Columbus first visited those islands. The best varieties of Sea Island cotton have been developed by careful seed selection and cultivation on James and Edisto islands, along the coast of South Carolina. This cotton is cultivated on other islands and the adjacent mainland in that region, and also in sandy soils in the interior, across southern Georgia and northern Florida. Fresh supplies of seed are brought from the coast every two or three years to keep up the quality of that grown in the interior. During the last two years the cultivation of Sea Island cotton has been reintroduced into Porto Rico and the British West Indies, and under improved conditions it seems likely to become more profitable there than before it was crowded out by the sugar industry.

The Sea Island plant differs from that of Upland cotton in its larger growth—3 to 8 feet high, with longer and more flexible branches, more deeply lobed leaves, bright yellow flowers, and sharp-pointed bolls, having three instead of four or five divisions or locks (Pl. XLV, fig. 3). The seeds are black or dark brown, and are not covered with a persistent fuzz. The lint is $1\frac{3}{8}$ to 2 inches long, finer and longer than that of Upland cotton, and usually softer and more lustrous. It commands a price ranging from 2 to 15 cents per pound more than Upland cotton, but it requires greater care in its production and is more exacting in regard to soil and climate. It yields less per acre (100 to 300 pounds), and costs more to pick and to gin. It is used in making fine threads for sewing and for laces, fine yarns for fancy hosiery, for weaving into the finest lawns and dimities, and generally for the most expensive grades of cotton goods.

An important derivative of Sea Island cotton is that known as long-staple Upland, obtained by careful selection from hybrids of Sea Island and Upland cotton. The long-staple Upland cottons are cultivated chiefly in the rich alluvial soil of the Yazoo delta in Mississippi. The lint is intermediate in character between Sea Island and Upland cotton.

EGYPTIAN COTTON.

Another still more important derivative of the Sea Island type is Egyptian cotton, cultivated on the irrigated lands of Egypt, where

scarcely any rain falls from the time the seed is planted in March until the last of the crop is picked in November. Many generations of growth under these conditions, and possibly some hybridization with India cotton, have developed a peculiar quality of lint especially adapted to the manufacture of hosiery yarns and mercerized goods. The United States imports Egyptian cotton to the value of $7,000,000 to $10,000,000 each year, and the demand is steadily growing, owing to the increasing use of knit goods and the continued popularity of the silk-like mercerized cotton goods.

INDIA COTTON.

The cotton of East India, next in importance, is obtained chiefly from a species of plants native in southern Asia, *Gossypium herbaceu* (Pl. XLVI, fig. 3). The plants differ from American Upland cotton in their more slender, less woody stems, with leaves having roundish instead of sharp-pointed lobes, and in the smaller, more nearly spheri cal bolls (Pl. XLV, fig. 3). The lint of some varieties is glossy white, of others dull, of some yellow, and of still others golden brown. It is generally coarser and shorter than American Upland cotton, ranging from one-half to an inch in length. Outside of India it is used chiefly for medium or coarse yarns and for mixing with other cotton. Very little of it is imported into this country. It is cultivated in Farther India, China, Bengal, Persia, Arabia, and the Levant.

PERUVIAN COTTON.

In South America, Peruvian cotton (*Gossypium peruvianum*) is cultivated chiefly in Brazil and Peru. This cotton, often called kidney cotton, is characterized by the seeds in each lobe of the capsule clinging together in a compact cluster. These seeds are black and without a persistent fuzzy covering. The lint shows a wide variation in color and texture—white, brown, reddish, rough and harsh, or smooth and soft. Most of it has a shorter, coarser, and more wiry fiber than that of American Upland. The lint of some varieties is much like wool in appearance. It is imported chiefly for mixing with wool or for producing special effects. Kidney cotton is found in Central America and also in the Philippines and other tropical islands of the Pacific, but it is not cultivated in commercial quantities outside of South America.

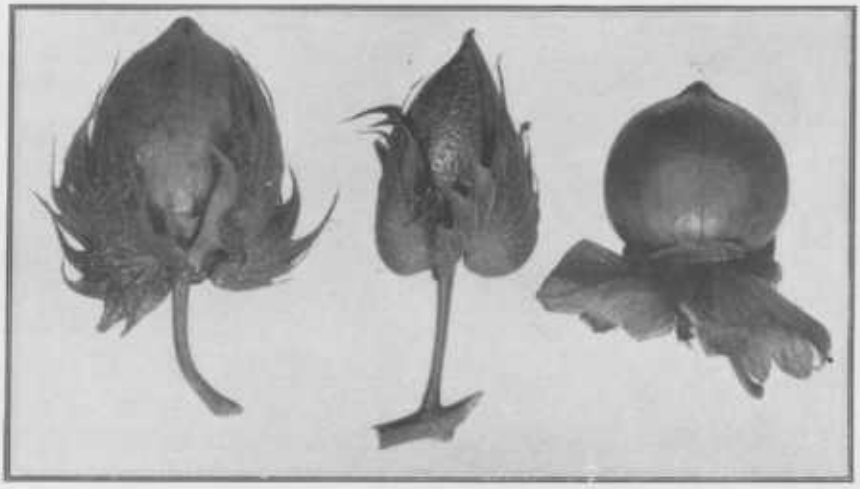
SOFT FIBERS.

FLAX.

The flax plant (*Linum usitatissimum*—Pl. XLVII, fig. 1) originated in western Asia in the region between the Caspian Sea and the Persian Gulf. It was doubtless one of the earliest plants cultivated for fiber, and from the times of the first authentic record until the advent of

FIG. 1.—SOFT FIBERS.
[*A*, Flax; *B*, Hemp, dew-retted; *C*, Hemp, water-retted; *D*, Jute.]

FIG. 2.—HARD FIBERS.
[*E*, Manila; *F*, Sisal; *G*, Mauritius; *H*, Istle.]



American Upland. Sea Island. India.

FIG. 3.—COTTON BOLLS.

Yearbook U. S. Dept. of Agriculture, 1903.

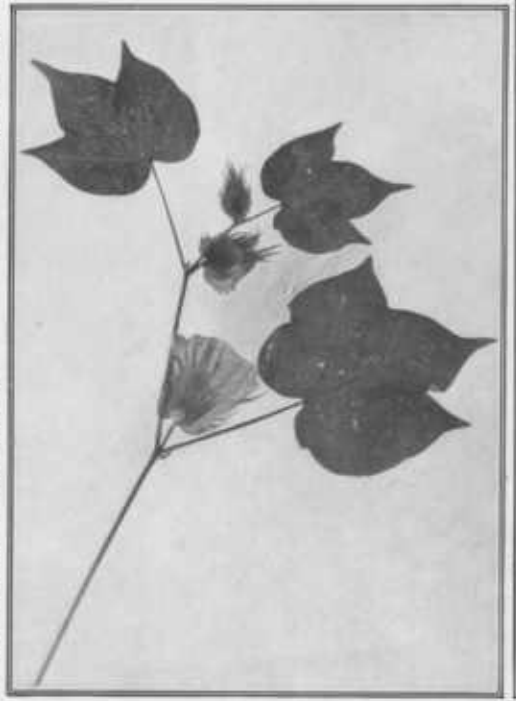


FIG. 1.—AMERICAN UPLAND COTTON (GOSSYPIUM HIRSUTUM).

FIG. 2.—SEA ISLAND COTTON (GOSSYPIUM BARBADENSE).

FIG. 3.—INDIA COTTON (GOSSYPIUM HERBACEUM).

cheaper cotton during the last century, it was used more extensively than any other vegetable fiber. In central and northern Russia, and in Holland, Belgium, Ireland, and northern Italy flax is still cultivated primarily for the production of fiber. In southern Russia, British India, Argentina, and the United States it is cultivated almost exclusively for seed production. In these regions the straw is burned, used for stable bedding, or sometimes for forage where there is a scarcity of hay. A small portion of the flax straw produced in North Dakota is used for paper stock, and in a few localities in the Dakotas, Minnesota, and Ohio it is made into upholstering tow. Only in the vicinity of Yale in eastern Michigan, at Northfield and Heron Lake, Minn., and at Salem and Scio, Oreg., is flax cultivated in this country for the production of spinning fiber. In all these localities the seed is saved, and it is doubtful if the industry would yield sufficient profits from the production of fiber alone to warrant its continuance under present conditions. All of the fiber flax of this country, as well as that of Ireland, Belgium, and Holland, is grown from seed of Russian origin. The plants deteriorate when grown from seeds of the third or fourth generation in this country, and unless special attention is given to selection and the production of improved strains it is necessary to import a new stock every three or four years.

Flax is a rather dainty surface feeder, with a small root system, yet it must make a rapid growth, reaching maturity in about one hundred days. It requires a soil with a sufficient amount of fertilizing elements readily available. It is apparently of still greater importance that the soil be continually moist during the growing season, and for the production of the best quality of fiber a moist atmosphere is essential. Carefully conducted experiments, as well as the observations of practical flax growers, have proved conclusively that this crop does not draw on the fertility of the soil as much as wheat, oats, or barley. It can not be cultivated year after year on the same land, because of a disease,[a] flax-wilt, the spores of which remain in the soil, infecting future crops. Since this disease does not attack other ordinary crops, flax may be introduced in a rotation, preferably after grass or pasture, once in six or eight years.

Flax is sown early in the spring, broadcast, like oats or wheat, either by hand seeder or with a drill. The seed should be covered evenly, and to a depth not exceeding an inch—one-half inch is better. No further attention is required until the crop is harvested late in July or early in August. The best flax is pulled, for the following reasons: (1) To secure straw of full length; (2) to avoid stain and injury which would result from soil moisture soaking into the cut stems while curing in the shock; (3) to secure better curing of the straw and ripening of the seed;

[a] Bolley. Bulletin No. 50, North Dakota Experiment Station.

and, (4) to avoid the blunt cut ends of the fiber. Flax that has not grown well enough to produce first-grade fiber is sometimes cut with a self-rake reaper. After curing in the shock for two or three weeks the seed is thrashed out, usually by holding an unbound bundle in the hands and passing the heads two or three times between rapidly revolving rollers which crush the seed pods, the seed afterwards being cleaned in a fanning mill. The straw is then bound into bundles and stored until time for retting, in October or early November. Nearly all of the fiber flax grown in the United States and Canada is retted by spreading the straw carefully and evenly on the ground, where it is exposed to the weather for two to four weeks. After retting, it is raked up, tied in bundles, and taken to the mills, where it is broken, scutched, and hackled. In each of these operations it is picked up and handled in small handfuls, and some of the processes, especially hackling, require a high degree of skill. Numerous machines have been invented to pull flax, spread it for retting, break it, and scutch the fiber, but none of them has given sufficient satisfaction to be generally adopted. Until machines are devised to take the place of hand labor and reduce the cost of the preparation of flax fiber there is little probability that the industry in this country can be increased in competition with other crops which may be cultivated with greater profit.

The importations of flax fiber amount to about $2,000,000 annually. Most of this comes from Russia, Belgium, and Holland. In Belgium and Holland the flax is retted by soaking in water, which produces a whiter, softer fiber, but the process is more laborious and expensive than the dew retting practiced in this country.

Flax fiber is from 12 to 36 inches in length, silvery gray when dew retted, yellowish white when water retted, capable of fine subdivision, soft and flexible, and is the strongest of the fine commercial bast fibers. It is used for making linen sewing thread, shoe thread, bookbinders' thread, fishing lines, seine twine, the better grades of wrapping twine and knit underwear, and for weaving into handkerchiefs, toweling, table linen, collars and cuffs, shirt bosoms, and dress goods. The finer grades of linen damasks are imported, as the weaving of these goods is slow work, and requires a kind of labor not commonly found in this country.

HEMP.

Hemp (Pl. XLVII, fig. 2) originated in western Asia. Like flax, it was cultivated for fiber several centuries before the Christian era, and, next to flax, it was the most extensively used vegetable fiber until the introduction of cheaper cotton and jute. Hemp is now cultivated commercially in Russia, Austria-Hungary, Italy, Turkey, China, Japan, and the United States. In Europe several rather distinct varieties of hemp are grown, the principal types being the Piedmont of France

and northern Italy; the Neapolitan of southern Italy; the Smyrna of Turkey and Asia Minor; and the Russian of Russia and Hungary. All of these, and also the Japanese, Chinese, and Kentucky (or China-American) hemp, belong to the same species, *Cannabis sativa* L. This is the only true hemp, but the name hemp is unfortunately applied to many other fibers, most of which are quite different in character. About 15,000 acres in this country are annually devoted to hemp production. Nearly all of this is in the bluegrass region of Kentucky. Small areas—less than 1,000 acres in all—are cultivated near Lincoln, Nebr., and at Gridley and Rio Vista, Cal. The total production of hemp fiber, varying from 6,000 to 9,000 tons, is not sufficient to supply the demands of our manufacturers, and more than 4,000 tons are imported annually, chiefly from Italy and Russia. Hemp fiber, prepared by water retting as practiced in Italy, is of a creamy-white color, lustrous, soft, and pliable. It makes a satisfactory substitute for flax, and is used for medium grades of nearly all classes of goods commonly made from flax, except the finer linens. When prepared by dew retting as practiced in this country, the fiber is gray, and somewhat harsh to the touch. It is used for yacht cordage, ropes, fishing lines, linen crash, homespuns, hemp carpets, and as warp in making all kinds of carpets and rugs.

JUTE.

Jute fiber is obtained from two closely related species, *Corchorus olitorius* and *Corchorus capsularis*, native in Asia. Both are cultivated largely in Bengal, India, and to a less extent in China, Japan, and Formosa. The plants are annuals, belonging to the linden family. In general habit of growth they resemble Kentucky hemp, attaining a height of 8 to 12 feet, with no branches or only a few small ones near the top. Jute grows best in rich alluvial soils along rivers. The seed is sown in the spring, either broadcast in the field or sometimes in carefully prepared beds, from which the seedlings are afterwards transplanted. The plants are harvested either by cutting close to the ground or by pulling them up by the roots. In Formosa the fiber is stripped from the fresh green stalks as soon as pulled, and these ribbons, called "hemp skins," are afterwards retted by soaking them in water, and the fiber cleaned by drawing it between a blunt knife and a block of wood. In India the jute is either cut or pulled, and is retted by immersing the bundles of stalks in water. The fiber is afterwards cleaned by hand processes from the wet stalks.

The coarser fiber from the base of the stalks, 5 to 25 inches in length, is cut off and placed upon the market as jute butts. The remainder of the fiber is fine, soft, glossy, pliable, and easily spun. When fresh it is of a light creamy-white color, but it changes to a dingy yellow upon exposure. It also loses its strength, especially if exposed

to moisture. It is the cheapest fiber used in American textile manufactures, and it is employed in greater quantities than any other except cotton and sisal. Jute butts, ranging in price from 1 to 2 cents per pound, are used for making paper, and also for coarse bagging, cotton-bale covering, and the cheaper grades of twine. The longer fiber, selling in this country for 2¾ to 3¼ cents per pound, is used for wool twine, binder twine, jute rugs and carpets, grain sacks, and even for filling in heavy silk goods. The importations of jute fiber and jute butts amount to more than 100,000 tons a year, and the consumption in this country is steadily increasing. Experiments in the cultivation of jute in this country have proved that the plants may be grown successfully in the Southern States, but without suitable machinery for preparing the fiber the industry can not be carried on profitably.

HARD FIBERS.

MANILA FIBER.

Manila fiber, often called manila hemp, is obtained from the leaf sheaths of a kind of banana plant native in the Philippines. There are several varieties recognized in the different provinces, but all are known by the name abacá, and all have been regarded heretofore as belonging to one species, *Musa textilis* (Pl. XLVIII, fig. 1). Recent investigations conducted by the Bureau of Agriculture of the Philippines indicate that there are probably several distinct but closely related species cultivated for the production of manila fiber.

Abacá plants are cultivated successfully only in a comparatively small portion of the Philippines—in southern Luzon, and in Mindanao, Negros, Leyte, Cebu, Masbate, Mindoro, Marinduque, and Samar. In these regions there is an abundant rainfall and a relatively high humidity of the atmosphere. The plant grows best in volcanic soil on hillsides where there is good natural drainage. It can not be grown successfully in wet, swampy land or in soil that becomes dry.

The plants are propagated chiefly by suckers, which spring from the roots of mature plants. These are set out in rows 5 to 8 feet apart in each direction. Cultivation consists chiefly in cutting down weeds which would otherwise grow up and choke out the abacá. About three years are required for the plants to reach maturity when propagated from cuttings, or about five years when grown from seeds. They attain a height of 8 to 20 feet, the trunk being composed chiefly of overlapping leaf sheaths. When the flower bud appears the entire plant is cut off close to the ground. The leaf sheaths, 5 to 12 feet in length, are stripped off, separated tangentially into layers a quarter of an inch or less in thickness, and these in turn split into strips 1 to 2 inches in width. While yet fresh and green these strips are drawn by hand under a knife held by a spring against a piece of wood. This scrapes away the pulp, leaving the fiber clean and white. After

Yearbook U. S. Dept. of Agriculture, 1903.

FIG. 1.—FLAX GROWN FOR FIBER AT NORTHFIELD, MINN., READY FOR HARVEST.

FIG. 2.—HEMP ON ALLUVIAL SOIL AT GRIDLEY, CAL.

FIG. 1.—ABACA, SEEDLING OF PLANT PRODUCING MANILA FIBER.

FIG. 2.—NEW ZEALAND "FLAX."

FIG. 3.—SISAL PLANTS, GROWING IN THE BAHAMAS.

drying in the sun the fiber is tied in bunches and taken to the principal towns or to Manila to be baled for export.

The average yield of fiber is about 650 pounds per acre. The price in the New York market during the past ten years has ranged from 4 to 14 cents per pound. Manila fiber ranks first among the resources of the Philippine Islands, amounting to more than 60 per cent of the total value of exports. The importation of this fiber into the United States has been rapidly increasing since the war of 1898. During the calendar year 1903 more than 500,000 bales of 270 pounds each were brought to this country.

The best grade of manila fiber is of a light buff color, lustrous, and very strong, in fine, even strands 6 to 12 feet in length. Poorer grades are coarser and duller in color, some of them yellow or even dark brown, and lacking in strength. The better grades are regarded as the only satisfactory material known in commerce for making hawsers, ships' cables, and other marine cordage which may be exposed to salt water, or for well-drilling cables, hoisting ropes, and transmission ropes to be used where great strength and flexibility are required. The best grade of binder twine is made from manila fiber, since owing to its greater strength it can be made up at 650 feet to the pound as compared with sisal at 500 feet.

SISAL.

The sisal plant (*Agave rigida*) usually known as henequen in Spanish-speaking countries, is native in Yucatan (Pl. XLVIII, fig. 3). It has been introduced in many other tropical countries, but its cultivation for fiber on a commercial scale is confined to Yucatan, the Bahamas, Turks Island, Cuba, and Hawaii. Recent plantations have been made in Venezuela, in Santo Domingo, and in the Bombay and Madras presidencies in India.

The sisal plant requires for its best development a soil composed chiefly of limestone and a warm and comparatively dry climate. Clear, dry weather, with bright sunshine, is required to dry and bleach the fiber, while in rich, moist soil or in a moist climate the leaves develop too large an amount of pulp in proportion to the fiber.

The sisal plant is propagated by suckers springing from the roots of old plants, or from bulbils. Bulbils, called "mast plants," are produced in great numbers on the flower stalks in place of seed pods, like onion sets. The plants are set out during the rainy season, in rows 4 to 8 feet apart, in holes dug in partly disintegrated coral or lime rock with crowbars, pickaxes, and sometimes with the aid of dynamite. The ground where sisal is grown is usually too rocky to permit any stirring of the soil. About the only care given is to cut the brush and weeds once or twice each year. The weeds and brush, largely leguminous plants, by decaying on the ground add fertility to the soil. The first crop of outer leaves of the plants is cut at the end of three years when grown

from suckers, or four years when grown from mast plants. From ten to twenty leaves are produced each year for a period of twelve to twenty-five years in Yucatan, ten to fifteen years in Cuba, and six to twelve years in the Bahamas. An unusually cold winter at any period tends to check growth and cause the plants to send up flower stalks, after which they die.

Sisal fiber is cleaned from the leaves by machines which scrape out the pulp and at the same time wash the fiber in running water. It is then hung in the sun to dry and bleach for from one to three days, after which it is baled for market. The average annual yield is about 600 pounds of clean, dry fiber per acre. The price during the past ten years has varied from 2¾ to 10 cents per pound. More than 600,000 bales, averaging about 360 pounds each, were imported during the calendar year 1903.

Sisal fiber of good quality is of a slightly yellowish-white color, 2½ to 4 feet in length, somewhat harsher and less flexible than manila fiber, but next to that the strongest and most extensively used hard fiber. It is used in the manufacture of binder twine, lariats, and general cordage, aside from marine cordage and derrick ropes. It can not withstand the destructive action of salt water, and its lack of flexibility prevents it from being used to advantage for running over pulleys or in power transmission. It is used extensively in mixtures with manila fiber.

NEW ZEALAND HEMP.

The plant producing the fiber known in our markets as New Zealand hemp or New Zealand flax is a perennial belonging to the lily family, and is technically known as *Phormium tenax* (Pl. XLVIII, fig. 2). It is native in the coast regions of New Zealand, and is cultivated commercially only in those islands. The plant is hardy, withstanding a considerable degree of cold and drought. It is cultivated as an ornamental plant in parks and private grounds in the coast region of California, and also on the west coasts of Ireland and Scotland. Several different varieties are cultivated in New Zealand, some with leaves 6 to 8 feet long, others with leaves only half that length, 1½ to 3 inches in width, and of rather thin texture. The fiber is cleaned from the freshly cut leaves by scraping, washing, and drying. The scraping process is performed chiefly by machinery, but no machine has yet been used which will do all of the work satisfactorily.

The fiber is 40 to 60 inches long, nearly white, fine, and rather soft for a leaf fiber. It is used as a substitute for sisal in binder twine, baling rope, and medium grades of cordage, and is made up largely in mixtures with manila or sisal, except in the cheaper tying twines. By extra care in preparation and hackling, a quality is produced almost as fine and soft as the better grades of flax, and when thus prepared it may be spun and woven into goods closely resembling linen. Before

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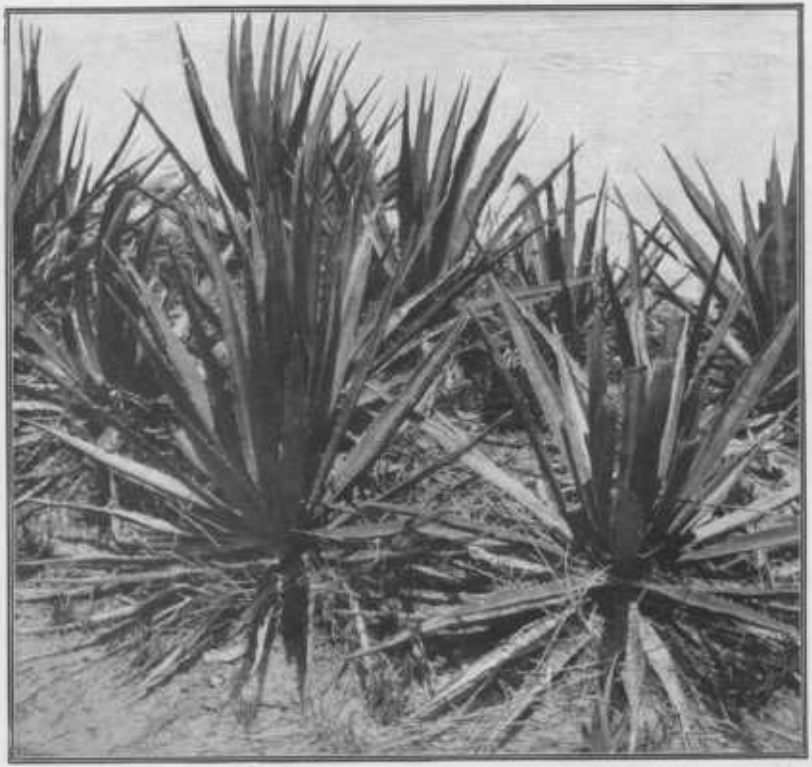

FIG. 1.—LECHUGUILLA PLANTS, PRODUCING JAUMAVE ISTLE.

FIG. 2.—PALMA SAMANDOCA, FROM WHICH PALMA ISTLE IS OBTAINED.

being exported from New Zealand the fiber must all pass a rigid inspection, to insure uniformity in grading and prevent the shipment of inferior qualities. Since this system of inspection went into effect, in 1901, the importations of New Zealand hemp into this country have increased from 3,915 to 10,674 tons annually, and the price has advanced from $110 to $142 per ton.

MAURITIUS.

Mauritius fiber or mauritius hemp, as it is often called in the market, is obtained from the large, fleshy leaves of an agave-like plant (*Furcræa fœtida*). This plant is widely distributed in the tropics of both hemispheres. In Porto Rico it is known as maguey, probably from its resemblance to the maguey of Mexico, and in Hawaii it is called malino, a corruption of manila.

The fiber is produced commercially only on the island of Mauritius, though there seems to be no good reason why the industry should not succeed elsewhere. The plant is more hardy and thrives under a greater diversity of soil and climatic conditions than any other important fiber plant of this class. It is propagated by suckers or by bulbils in the same manner as sisal, and the fiber is cleaned partly by machinery. The preparation of the fiber involves the same processes, scraping, washing, and drying, as in the case of sisal. Under favorable conditions the yield ranges from 1,000 to 1,500 pounds per acre. The fiber is whiter and softer than other hard fibers, but it is weaker than sisal. It is used in the manufacture of gunny bags, halters, and hammocks, but more largely for mixing with manila and sisal in making medium grades of cordage. When the better grades of cordage fiber (manila and sisal) are abundant and quoted low in the market, mauritius is likely to fall below the cost of production.

ISTLE.

The increasing demand for cordage and twines of all kinds during the past few years has led to the substitution of istle fiber for the cheaper grades, whereas this fiber had been regarded heretofore as suitable only for use in the manufacture of brushes.

Istle or Tampico fiber is produced by four or five different species of plants which grow on the high arid table-lands of northern Mexico. The most important of these are the Jaumave lechuguilla (pronounced How-mah'-ve lech-u-guee'l-ya), producing the best grade, Jaumave istle (Pl. XLIX, fig. 1); lechuguilla, producing a medium grade, Tula istle; and palma samandoca and palma pita, producing palma istle, about equal in value to Tula istle.

The production of Jaumave istle is confined chiefly to the fertile Jaumave Valley, about 70 miles by road over the mountains south of Victoria, in the State of Tamaulipas. The fiber is obtained from the leaves of an agave plant, known technically as *Agave lophantha*. The

plant is not cultivated, but it grows abundantly on the mountain sides and out on the gravelly plain at the base of the mountains. Only the young inner leaves, forming the central spindle-like bud, are used. These are collected and the leaves taken up one by one and cleaned by drawing them, first one end then the other, under a blunt knife pressed against a block of wood. More than 30 tons of this fiber are produced in the vicinity of Jaumave every week, and all of it is shipped on the backs of burros over the mountains, a long two days' journey, to the railway at Victoria.

Tula istle is obtained from the lechuguilla plant (*Agave lecheguilla*), which is widely distributed on the high lands of Mexico and extends into western Texas and New Mexico. The fiber is produced most abundantly in the vicinity of Tula, about 60 miles south of Jaumave, in the State of Tamaulipas. It is obtained from the inner leaves of the plant, and is cleaned in exactly the same manner as Jaumave istle.

Palma istle is obtained from the inner leaves of yuccas, known in Mexico as palmas. The species producing most of this fiber is called palma samandoca (*Samuella carnerosana*—Pl. XLIX, fig. 2). This plant has a trunk 6 to 15 inches in diameter, and attains a height of 6 to 15 feet, bearing at the top a dense cluster of sword-like leaves, 20 to 30 inches long. Some of the palma istle is produced by the plant known as palma loco, or palma pita (*Yucca treculeana*), found in Coahuila and Nueva Leon. This yucca is very similar in appearance to palma samandoca, though usually with shorter trunk and longer leaves. The central cluster of unopened young leaves is collected and cleaned in the same manner as the leaves of the lechuguilla plants, except that they have to be steamed two to four hours to loosen the tissues before the pulp can be scraped out. The fiber is discolored by the steaming process, but this is partly corrected by bleaching in the sun as it dries.

Palma istle fiber is 15 to 35 inches in length, usually coarser and stiffer than sisal, yellow in color, and somewhat gummy. Tula istle is 12 to 30 inches long and nearly white in color. Jaumave istle is 20 to 40 inches long, rarely longer, almost white, and nearly as strong and flexible as sisal. The importations of istle fiber into the United States have increased from less than 4,000 tons in 1900 to more than 12,000 tons in 1903. Istle fiber has long been used as a substitute for bristles in the manufacture of brushes, and it is now being employed in increasing quantities in the cheaper grades of twine, such as lath twine, baling rope, and medium grades of cordage. Introduced at first as an adulterant or substitute for better fibers, it seems destined to find, through improved processes of manufacture, a legitimate place in the cordage industry. If machines are devised for cleaning this fiber in a satisfactory manner it is thought that the thousands of acres of lechuguilla plants in western Texas may be profitably utilized.